NASA TECHNICAL TRANSLATION NASA TT F-15,569

PROCESS AND DEVICE FOR ADAPTATION OF SHARP LEADING EDGE AIRFOILS TO ANY SPEED, SUBSONIC OR SUPERSONIC

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(NASA-TT-F-15569) PROCESS AND DEVICE FOR ADAPTATION OF SHARP LEADING EDGE AIRFOILS TO ANY SPEED, SUBSONIC OR SUPERSONIC (Kanner (Leo) Associates) 27 p HC $4.50 CSCL 01A G3/01
N74-21631
Unclas
36290

Translation of "Procédé et dispositif d'adaptation des profils aérodynamiques à bord d'attaque aigu à une vitesse quelconque, subsonique ou supersonique," Patent of Invention, No. 1,071,234, France, Filed Nov. 19, 1952

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,569	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PROCESS AND DEVICE FOR ADAPTATION OF SHARP LEADING EDGE AIRFOILS TO ANY SPEED, SUBSONIC OR SUPERSONIC		5. Report Date April 1974
		6. Performing Organization Code
7. Author(s) Southwest National Aeronautic Design Company, Inventor , Seine, France		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates, P.O. Box 5187 Redwood City, California 94063		11. Contract or Grant No. NASw-2481
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Procédé et dispositif d'adaptation des profils aérodynamiques à bord d'attaque aigu à une vitesse quelconque, subsonique ou supersonique," Patent of Invention, No. 1,071,234, France, Filed Nov. 19, 1952.

16. Abstract

Since airfoils with a sharp leading edge are highly advantageous in supersonic flight but produce excessive drag, among other problems, at the subsonic speeds necessary to attain supersonic flight, the invention under consideration is designed to change the configuration of sharp leading edge airfoils during flight to maximize their efficiency in any speed range. The primary mechanism used is a deflecting or slotted flap with sharp leading edge which can be used in aircraft wings, stabilizers or air intakes; deflection of this flap brings the airflow into a position tangential to the edge and the shock wave strikes the edge itself or the area in its immediate vicinity. A complex series of pressure measurement devices enables the pilot or an automatic control system to make the proper change in the deflection of the flap as a function of the speed of the aircraft.

17. Key Words (Selected by Author(s))		18. Distribution Statement Unclassified - Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 22	22. Price 4.50

NASA-HQ

PROCESS AND DEVICE FOR ADAPTATION OF SHARP LEADING EDGE AIRFOILS TO ANY SPEED, SUBSONIC OR SUPERSONIC

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The use of aircraft traveling at supersonic speeds has revealed /1* the disadvantages of using a normal subsonic airfoil -- that is, an airfoil with a rounded leading edge -- at these speeds. At supersonic speeds the shock wave is detached and curved if the leading edge is rounded, thus producing a field of subsonic speeds in the neighborhood of the leading edge, in turn resulting in an increase in pressure on the wall of the airfoil and a considerable increase in its drag. To correct these disadvantages, airfoils used for supersonic speeds are given a sharp leading edge with a relatively flat profile angle, and at these speeds the shock wave is attached to the tip of the airfoil. The flow is completely supersonic and there is little drag.

However, in order to reach supersonic speeds the aircraft must first travel at subsonic speeds, and here airfoils with a sharp leading edge have extremely unfavorable aerodynamic properties. If the lift is not zero, the drag is greater than that of an airfoil with a rounded leading edge. Overspeeds occur at the leading edge, entraining extremely high negative pressure if the flow is not at a tangent, and these overspeeds may result in boundary-layer separation.

These drawbacks are especially notable in regard to the air intakes. Until now the cross-section of these normally divergent

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intakes, which are used in high-speed or subsonic rotary wing aircraft, has been fixed, with the result that the edge of the entry casing is given a wide curvature which, aside from the disadvantages indicated above, necessitates heavy fairings for the air ducts. The overall size of these fairings does not favor the attainment of highly improved aerodynamic profiles with a low maximum cross-section, a disadvantage whose significance may be decreased by the use of casings with a sharp leading edge, with the disadvantages cited above, however. Consequently the conventional air intake produces drag at the same time that it is responsible for the amount of thrust generated by the jet engine which it supplies. The sole criterion for the quality of this type of air intake is the resultant force, that is, thrust minus drag. Poor adaptation of the entry cross-section slows the speed of the aircraft, whether this cross-section is too large or too small, since the resultant force exerted in the direction of flight decreases either because of external drag or because of a decrease in thrust.

Moreover, when the aircraft flies at supersonic speeds, the shape of the shock wave depends not only on the shape of the leading edge of the contoured panel(s) of the air intake, but also on the flow within this air intake if this flow is decelerated to subsonic speeds at the end of the intake, which is always the case when the intake is feeding a jet engine. If the downstream pressure of this flow is too high, the flow upstream from the sharp leading edge of each contoured panel is decelerated and a detached shock wave is produced. The deformation of this sharp leading edge produces a local separation on the outside of the contoured panel, resulting in an appreciable increase in the drag generated by the air intake. If, on the other hand, the downstream pressure of the flow in the intake is too low, a shock wave is produced in this intake at a higher supersonic speed than the upstream supersonic speed, and the drag generated by the intake remains low due to the increase in pressure losses. These losses increase as a function of the distance of the shock wave from the leading edge of each contoured panel, that is, within an area where the boundary layer is higher and where the increase in pressure easily produces a separation of this layer.

In order to correct these drawbacks, in the invention under consideration the airfoil of the contoured panel(s) of the air intakes is given a sharp leading edge which consists of a deflecting or slotted flap with sharp leading edge; the deflections of this flap assure that the flow will be tangential to this edge at subsonic speeds and that at supersonic speeds the shock wave will be kept on the sharp leading edge or inside the intake in the neighborhood of this sharp edge. In subsonic flight the negative pressure point is thus relegated to a position above the hinge-pin of the flap and the maximum negative pressure is appreciably decreased, since the greater part of the negative pressure is distributed over the curved area formed by the deflection of the flap; as a result, boundary-layer separation is limited and drag is reduced. /2

However, merely using the control system of the aircraft or reading an ordinary control instrument such as an engine control instrument, the pilot is completely unable to foresee what maneuvers will be required to bring the deflecting or slotted flap with sharp leading edge of each air intake panel into the desired position as a function of the speed of the aircraft.

To help remedy the lack of information furnished to the pilot, an additional object of this invention is to provide a process for adapting to any given speed, subsonic or supersonic, a contoured air intake panel consisting of a deflecting or slotted flap with sharp leading edge. In this process, the flow at this flap is measured at each subsonic speed and the deflection of the flap is adjusted until this flow is tangential to it; the position of the shock wave in relation to the flap is determined for each supersonic speed and the deflection of the flap is adjusted in such a way that the shock wave is located on its sharp edge or inside the intake in the immediate vicinity of this sharp edge.

The sharpened edge of the flap, however, will always be somewhat rounded, even though this rounding will be minimal. Consequently there are two flow limits within which the flap will operate satisfactorily at subsonic speeds, even though the flow is not exactly tangential to the flap. These limits are proportional to the dynamic pressure of the undisturbed flow and may be definitively determined by means of tests on a given contoured air intake panel with a flap with sharp leading edge.

In supersonic flight the flow upstream from the shock wave is supersonic and the flow downstream is subsonic. The pressure gradient is therefore positive downstream and negative upstream from the shock wave, provided that the airflow is divergent.

Taking the test results into account, an attractive method for applying the above process to subsonic speeds would include the following: measurement of the difference between the external and internal pressure, measured at neighboring points on the flap equidistant from the sharp leading edge and respectively located on the outer and inner surfaces of the flap profile in relation to the intake; comparison of this pressure difference to two negative and positive fractions of the dynamic pressure of the undisturbed flow, definitively determined for the airfoil under consideration, and pivoting of the flap to close or open the angle of deflection, depending on whether this pressure difference is less than the negative fraction or greater than the positive fraction of the dynamic pressure; measurement, at supersonic speeds, of the difference between the rear pressure and the forward pressure, measured at two distinct points located on the inner surface of the flap airfoil in relation to the intake, in the vicinity of the leading edge; comparison of this pressure difference to a predetermined fraction of the ambient static pressure, and pivoting of the flap to close or open the angle of deflection, depending on whether the pressure difference is positive and less than this fraction of the ambient static pressure or negative and less than this fraction of the ambient static pressure.

The point of measurement on the outer surface and the rear measurement point on the inner surface of a single contoured panel are preferentially located at the same distance from the leading edge of the flap.

For flight at subsonic speeds, the process specified above makes it possible to obtain a flow tangential to the movable flap of each contoured panel by obtaining a flow which is symmetrical around an average line of the airfoil of this flap in the vicinity of the tip. If the flap is opened too far the air will circumvent it toward the outside; a negative pressure field is thus set up outside the intake and an overpressure field occurs inside it. It is these pressure differences which, combined with the dynamic pressure characterizing the speed, determine the indication to be given to the pilot or the action of an automatic control device during subsonic flight.

For flight at supersonic speeds, the flap of each contoured panel is operating satisfactorily if the shock wave occurs in the vicinity of its sharp leading edge. The pressure distribution over the surface internal to the intake furnishes all the necessary information on the position of the shock wave. If the shock wave is upstream from the closest measurement point on the tip, the pressure occurring at this point is less than that occurring at the farthest measurement point on the tip. On the other hand, if the shock wave is behind the rear measurement point, the pressure occurring at the forward measurement point is greater. Thus the pressure difference changes sign if the shock passes from an upstream to a downstream position in relation to these two measurement points. If the shock wave is located between these two points, the pressure difference will also obviously be positive, but its size is so much in excess of the value corresponding to the upstream shock wave that it is impossible to confuse the two. The position of the flap is correct if the difference in the forward and rear pressures exceeds a well-defined maximum positive value which is a constant fraction of the static pressure. It is these pressure differences which, combined with the static pressure, determine the indication to be given to the pilot or the action of an automatic control device in supersonic flight. /3

In this invention, for aircraft capable of subsonic flight only, the process of adaptation of the contoured panel(s) of the air intake to the speed of the aircraft consists only in the first part of the method of application specified above.

This invention additionally includes an adaptation device permitting the implementation of the process specified above: this device includes a detector of the relative position of the deflecting or slotted flap with sharp leading edge of each contoured air intake panel in the airstream; a dynamic pressure detector estimating the speed of the aircraft; a static pressure detector; a synchronizer of the variations produced by the first and the second detector for subsonic flight and by the first and third detectors for supersonic flight, this synchronizer serving to convert the results obtained into mechanical movement or electrical activity; and an indicator for the pilot showing the direction of the change to be made in the deflection of the flap of each contoured panel, this indicator preferentially being replaced by an automatic control device changing the deflection of the flap in conformity with the results obtained by the synchronizer.

In an attractive design configuration the adaptation device permitting implementation of the process specified above will include a unit for measuring two negative and positive fractions of the dynamic pressure of the undisturbed flow; a second unit for measurement of a fraction of the ambient static pressure; a manometric unit for measurement of pressure differences; two ducts connected to this manometric unit, one of them terminating in an intake located on the inner surface of the flap in relation to the air intake, while the other may be connected either to a second intake located on the outer surface of the flap in relation to the air intake and at the same distance from the sharp edge as the first intake, or to a third intake located on the inner surface of the flap upstream from the first intake; a device for subsonic comparison of the difference between the external and internal pressures, measured between the second and first intakes, and the negative and positive fractions of the dynamic pressure of the undisturbed flow; a device for supersonic comparison of the measured pressure difference between the first and third intakes and the fraction of the ambient static pressure; and a manually or automatically controlled means of changing the deflection of the flap as a function of the data furnished by the comparative devices.

If the aircraft is used only at subsonic speeds, the device consists only of the first measurement unit, the manometric unit for pressure difference measurement, the first comparative device and the manual or automatic means of changing the deflection of the flap of each contoured panel of the intake, the second duct being connected solely to a second intake located on the outer surface of the flap in relation to the air intake, at the same distance from the sharp edge as the first intake.

In an attractive design configuration, the adaptation device in this invention includes a distributor which receives the pressures measured at the various intakes in the flap of the contoured air intake panel, the differences in these pressures being transmitted to a control device which controls a servo motor designed to change the angle of deflection of the flap. The control devices and the servo motor may operate semiautomatically or automatically, and they may be powered mechanically, electrically, hydraulically or pneumatically.

In addition this invention consists in applications of the above specified adaptation device to the airfoils with sharp leading edge used in wings and stabilizers for subsonic flight, with the deflecting or slotted flap, however, being kept in a fixed position for supersonic flight. For wings, however, since lift is not constant over the entire span the flap is divided into several independent parts, each of which is controlled separately.

The deflecting flap with sharp leading edge and its adaptation device may be used on all air intakes, whether they are dorsal or lateral, embedded or located in the wing root. The combined adaptation device with a circular intake with sharp leading edge may additionally be used for air intakes equipped with a core whose strokes replace the opening or closing of the angle of deflection of a deflecting flap.

The following description of the appended diagrams given as non-restrictive examples will furnish a satisfactory idea of how /4 this invention may be put into practical operation, the characteristics of the devices described naturally comprising part of the invention:

Fig. 1 shows the tip of a contoured air intake panel equipped with a deflecting flap with sharp leading edge in conformity with the invention;

Fig. 2 is a view in perspective of a wing equipped with deflecting flaps with sharp leading edge;

Fig. 3 is a schematic diagram of an air intake in the wing root in conformity with the invention;

Fig. 4 is a diagram of an indicator giving the position which should be assumed by the deflecting flap with sharp leading edge of an airfoil used at subsonic speeds;

Fig. 5 is a diagram of an indicator giving the position which should be assumed by the deflecting flap with sharp leading edge of a contoured air intake panel used at supersonic speeds;

Fig. 6 is a diagram of an automatic electrical control unit for the deflecting flap with sharp leading edge of the contoured air intake panel, usable at all speeds, subsonic or supersonic.

In the design shown in Fig. 1, the airfoil 1 belonging to an upper contoured air intake panel is equipped with a deflecting flap 2 with sharp leading edge 3 which pivots around a shaft 4. On the surface internal to the air intake, this flap is equipped with two pressure intakes 5 and 6 and, on its external surface, with a pressure intake 7 located at the same distance from the sharp tip 3 as the internal intake farthest to the rear, that is, intake 6. These intakes are connected by three conduits 9, 10 and 11 to a control device 8 not shown in this figure, intakes 6 and 7 with their conduits 10 and 11 being used for subsonic flight, while intakes 5 and 6 with their conduits 9 and 10 are used for supersonic flight. The control device 8 regulates a servo motor

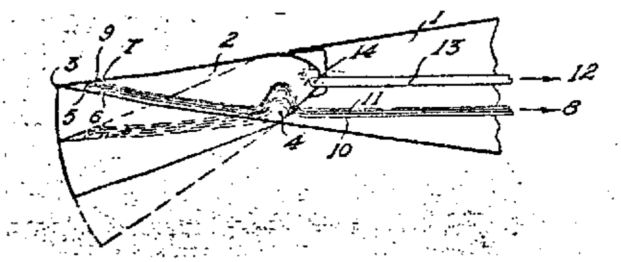
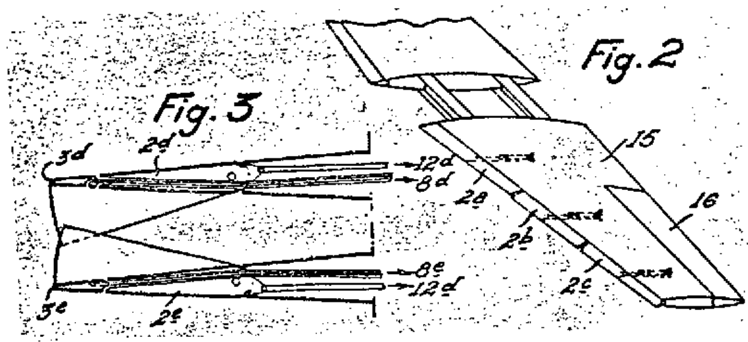


Fig. 1.

12 which is not shown, mounted on the fixed part 1 of the airfoil; by moving a rod 13 articulated 14 on the flap 2, this servo motor pivots the flap.

In cases where the airfoil constitutes a wing, as shown in Fig. 2, the deflecting flap with sharp leading edge is broken up into several independent parts 2a, 2b and 2c due to the fact that lift is not constant over the entire span, by reason of the variations in the effective angle of incidence along the wingspan produced by the deflection of an aileron 16 or by the characteristic shape of the wing. Each of the independent flaps 2a, 2b and 2c is equipped with an adjustment device of the type shown in Fig. 1, without intake 5 and conduit 9, the flap of the wing being adjusted only at subsonic speeds.



The design shown in Fig. 3 pertains to an air intake in the wing root. This air intake includes two contoured panels respectively equipped with deflecting flaps 2d and 2e with sharp leading edges 3d and 3e, each of which is equipped with an adjustment device of the type shown in Fig. 1, the reference numbers being assigned to the same components with the addition of the letters *d* and *e*. This intake is not sensitive to variations in the angle of incidence of the aircraft, since each deflecting flap automatically adopts the most favorable position corresponding to the angle of incidence and the airflow from the jet engine.

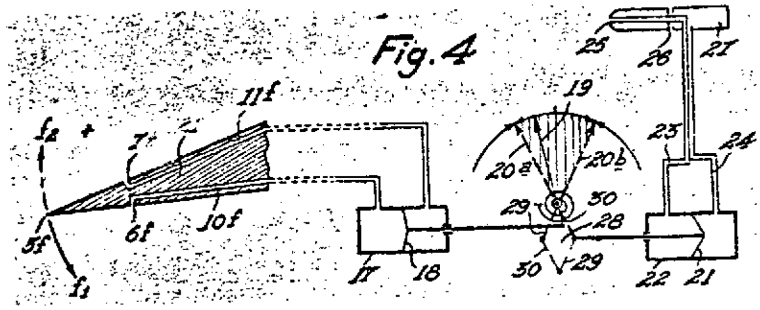


Fig. 4 shows the practical application of the preceding theoretical ideas for a deflection indicator for a deflecting flap with sharp leading edge at subsonic speeds only. This flap 2f of a wing, stabilizer or air intake is equipped with intakes 6f and 7f connected to conduits 10f and 11f. Conduits 10f and 11f are connected to a manometric capsule 17, to the front and to the rear of a membrane 18. The deformation of this membrane, which is proportional to the difference in the external pressure of intake 7f and the internal pressure of intake 6f, is transmitted to a needle 19 which moves on a dial. On the same dial are two additional needles 20a and 20b capable of moving opposite directions, and whose differences from zero position are proportional to the dynamic pressure. These needles indicate the margin of pressure differences for which the air intake operates satisfactorily. The two needles 20a and 20b are controlled in the same way as needle 19, by deformation of the membrane 21 of a second manometric capsule 22, which pipe systems 23 and 24 furnish with the total pressure and the static pressure occurring at the intakes 25 and 26 of a Prandtl tube 27. Transmission between the membrane 21 and the needles 20a and 20b is accomplished by means of an articulated parallelogram 28 in such a way that the fraction of the dynamic pressure indicated on the dial corresponds to the positive and negative limits of this pressure for which the flow does not separate from the profile of the flap. If these limits are not symmetrical in relation to the source, the arms of levers 29 and 30 of the transmission parallelogram 28 will not be of equal length.

If needle 19 is located between needles 20a and 20b, the position of flap 2f is correct (neutral zone). If its deviation is greater than that of needle 20a, the angle of deflection should be closed in the direction of the arrow f_1. On the other hand, this angle of deflection should be opened in the direction of arrow f_2 if needle 19 is at a greater inclination than needle 20b. The deviation of needle 19 varies as a function of the position of flap 2f in the airstream, while the positions of needles 20a and 20b are a function only of the general flow, that is the speed of the aircraft. /5

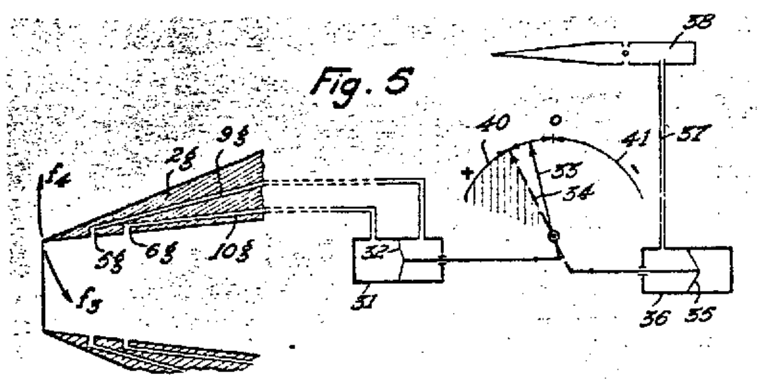


Fig. 5

Fig. 5 shows the practical application of the preceding theoretical considerations for a deflection indicator for the deflecting flap with sharp leading edge of a contoured air intake panel at supersonic speeds only, this flap 2g being equipped with intakes 5g and 6g connected to conduits 9g and 10g. Conduits 9g and 10g are connected to a manometric capsule 31, to the rear and to the front of a membrane 32. The deformation of this membrane is proportional to the difference in the rear intake pressure for intake 16 and the forward intake pressure for intake 5g, transmitted to a needle 33, which moves on a dial. The same dial is also equipped with a needle 34 controlled by the membrane 35 of a manometric capsule 36 connected by pipe 37 to a static probe 38 in such a way that the needle 34 indicates a fraction of the static pressure determining the positive threshold beyond which flap 2g operates satisfactorily. The dial is divided into two parts, a positive part 40 and a negative part 41.

If needle 33 is located beyond needle 34 in the shaded area of the diagram, the position of flap 2g is correct (neutral zone). If needle 33 is located between needle 34 and the guide mark 0 on the dial, the angle of deflection should be changed in the direction of the arrow f_3 to close the deflecting flap 2g, while if the same needle 33 is located opposite the negative zone 41, the deflection should be changed in the direction of arrow f_4 to open deflecting flap 2g. The deviation of needle 33 varies as a function of the position of flap 2g in the airstream, while that of needle 34 is merely a function of the ambient static pressure.

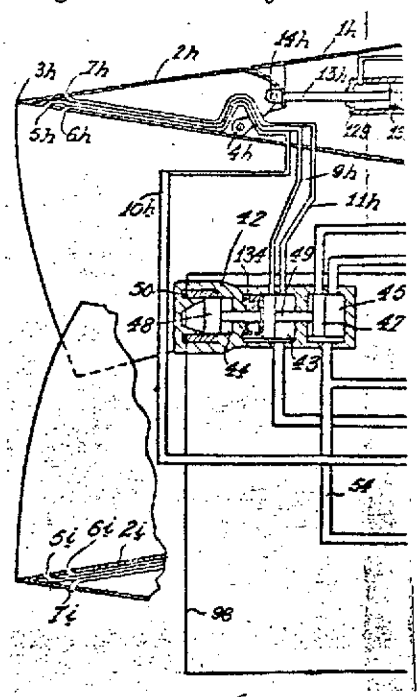


Fig. 6.

Fig. 6 shows a diagram of an automatic electrical control system for a contoured air intake panel which can be used at all speeds, subsonic and supersonic. The contoured panel 1h is equipped with a deflecting flap 2h with sharp leading edge 3h, articulated at 4h and equipped with three intakes 5h, 6h and 7h, intakes 5h and 6h being connected by conduits 9h and 11h to a distributor 42 which transmits the pressures occurring at the intakes to a control device 57, while intake 6h is connected by a conduit 10h to the same device 57, which controls a servo motor which in turn acts on rod 13h articulated at 14h on the deflecting flap 2h to change the deflection of this flap. Conduits 9h and 11h are connected to the center chamber 43 of a valve 42 consisting of three chambers 43, 44 and 45. These chambers respectively contain a center piston 46, an end piston 47 and a plunger 48, connected by a common shaft, the plunger 48 being controlled by an electromagnet 50. Chamber 45 is connected by two inlet pipes 51 and 52 to a static probe 38h and a Pitot probe 27h, respectively. In addition chambers 43 and 45 are equipped with outlet pipes 53 and 54.

Depending on the position of piston 46, the pressure at intake 7h or 5h is transmitted to pipe 53. Similarly, depending on the position of piston 47, whose motion is linked to that of piston 46, the Pitot pressure or the dynamic pressure is transmitted to pipes 54 and 61.

The rear intake 6h is in direct communication through conduit 10h with the manometric capsule 55 contained in a chamber 56 provided in the box 57 of the control device, this chamber also being connected to pipe 53. Pipe 54 is connected to a chamber 58 of the control box 57 in which a manometric capsule 59 is mounted. A third manometric capsule 60 is connected to a pipe 61 branching from pipe 54 and is contained in a chamber 62 of the control box 57, this chamber in turn being connected to a pipe 63 branching from pipe 51. The capsule 55 is equipped with a shaft 64 whose longitudinal displacement is proportional to the difference in pressure between intakes 5h and 6h or 6h and 7h. The movement of the shaft 64 is transmitted to two split supports 65 and 66 equipped with two electrical contacts 67 and 68. The distances of these contacts from the shaft 64 may be adjusted by means of two screws sliding in the two slots of supports 65 and 66 and insulated from them. Line 69 connects contact 67 to another contact 70 which is part of an electromagnetic circuit breaker whose other pole 71 is connected by line 72 to the servo motor. Contact 68 is connected to the servo motor by line 73. One of the poles of a source of electricity 74 is connected to the control box 57 and through the latter to a lever 75 which pivots around a shaft 76 maintained at the height of shaft 64 by a support 77. In addition another line 78 connects source 74 to the servo motor. Connecting rod 75 has two contacts 79 and 80.

Manometric capsule 59 is equipped with a shaft 81 supporting a split support 82; in the slot of this support is mounted an insulated contact 83 capable of being connected with contact 80 and whose distance from shaft 64 may be adjusted by means of a screw sliding along the slot of support 82. A line 84 connects this contact 83 to the winding 85 of the electromagnet 86, which is in turn connected by a line 87 to the source of current 74.

In addition, manometric capsule 60 is equipped with a shaft 88 at the end of which is mounted a bolt 89 able to move in a slot 90 cut in lever 75.

Moreover, contact 91 of an electromagnetic circuit breaker is
connected by a line 93 to line 69, the movable contact 94 of the /6
circuit breaker being connected by a line 95 to line 72. One of the ends of the winding 96 of the electromagnet is connected by a line 97 to one of the ends of winding 50, whose other end is connected to the source of current 74 by a line 98.

The device also includes a control unit sensitive to a Mach number which may be chosen in advance. This control device consists of a box 99 fitted with a chamber 100 subjected to static pressure by means of a conduit 101 connected to pipe 51. In chamber 100 is mounted a manometric capsule 102 equipped with a shaft 103 on whose end is mounted a bolt 104 designed to move in a slot 105 cut in a lever 106 articulated 107 on box 99. This box additionally includes a second chamber 108 subjected to the Pitot pressure by conduit 109 connected to pipe 52. In this chamber is mounted a manometric capsule 110 controlling a shaft 111 on which is mounted a split support 112 designed to support an insulated contact 113. The position of this contact may be adjusted by means of a screw in the slot of support 112; a line 114 connects this contact to the other end of the winding 96 of component 92. In addition, a line 115 provides an electrical connection between box 99 and box 57.

The servo motor includes an oil distributor 116 containing two pistons 117 and 118 mounted on a single shaft 119 counter to two adjustable springs; this single shaft is also equipped with a plunger 120 whose movements are controlled by two windings 121 and 122. These windings 121 and 122 have one end connected to line 78 and their other ends connected to lines 72 and 73 respectively. The chamber in which pistons 117 and 118 operate in opposition is connected by a pipe 123 to an oil pump and by a pipe 124 to a recycled oil tank. In addition, this chamber is connected by two conduits 125 and 126 to the two chambers of a hydraulic cylinder which is able to pivot around the shaft 130 mounted on a support 131 of the fixed part 1h of the contoured panel, the piston 132 of this cylinder controlling the maneuvering rod 13h. In a state of equilibrium, pistons 117 and 118 close both conduits 125 and 126.

The device thus described operates as follows:

At subsonic speeds, the effects of Pitot pressure predominate over those of static pressure. In the control unit 99, the movement of contact 113 under the action of capsule 110 subjected to this Pitot pressure is greater than the movement of lever 106 under the influence of capsule 102 subjected to the static pressure. Contact 113 closes on lever 106, closing the circuit: current source 74, box 57, line 115, box 99, lever 106, contact 113, line 114, winding 96, line 97, winding 50, line 98 and source 74. Windings 96 and 50 are excited. The effect of the excitation of winding 50 is to attract core 48, with the result that the pressure existing in intake 7h and chamber 58 and the Pitot pressure in capsule 60 are transmitted to chamber 56, capsule 55 being subjected to the pressure from intake 6h, and chamber 62 to the static pressure. Capsule 55 undergoes deformation proportional to the difference in the pressure inside and outside the air intake, measured at 7h and 6h, while capsule 60 undergoes deformation proportional to the dynamic pressure equal to the difference between the Pitot pressure and the static pressure. The deformation of capsule 60 results in a degree of inclination of lever 75 from neutral position proportional to the dynamic pressure. If the distances of contacts 67 and 68 from shaft 64 have been determined in proportion to the fractions of the dynamic pressure defining the limits of the neutral zone corresponding to the sharp leading edge of flap 2h, one of the three following possibilities may occur:

a. If the external pressure is lower than the internal pressure, that is, if the difference between the pressure at 7h and that at 6h is negative and greater in absolute value than that of the lower negative limit of the neutral zone, contacts 67 and 79 are closed and line 72 is supplied with current. At this point, winding 121 is excited; this winding attracts core 120, pipe 123 feeds conduit 126, and piston 132 is repelled in the direction of the flap, assuring closure of its angle of deflection;

b. If the external pressure is greater than the internal pressure, that is, if the difference between the external pressure and the internal pressure is positive and greater than the upper positive limit of the neutral zone, contacts 68 and 80 are closed and line 73 is supplied with current. At this point winding 122 is excited; it attracts core 120, pipe 123 feeds conduit 125, and piston 132 is retracted, resulting in the angle of deflection of flap 2h being opened;

c. If the difference between the external pressure and the internal pressure is between the two limits of the neutral zone, there is no contact between contacts 67 and 79 or between contacts 68 and 80, and flap 2h remains in its present position.

The excitation of winding 96 maintains the supply of current to line 72 by closing circuit breaker 94.

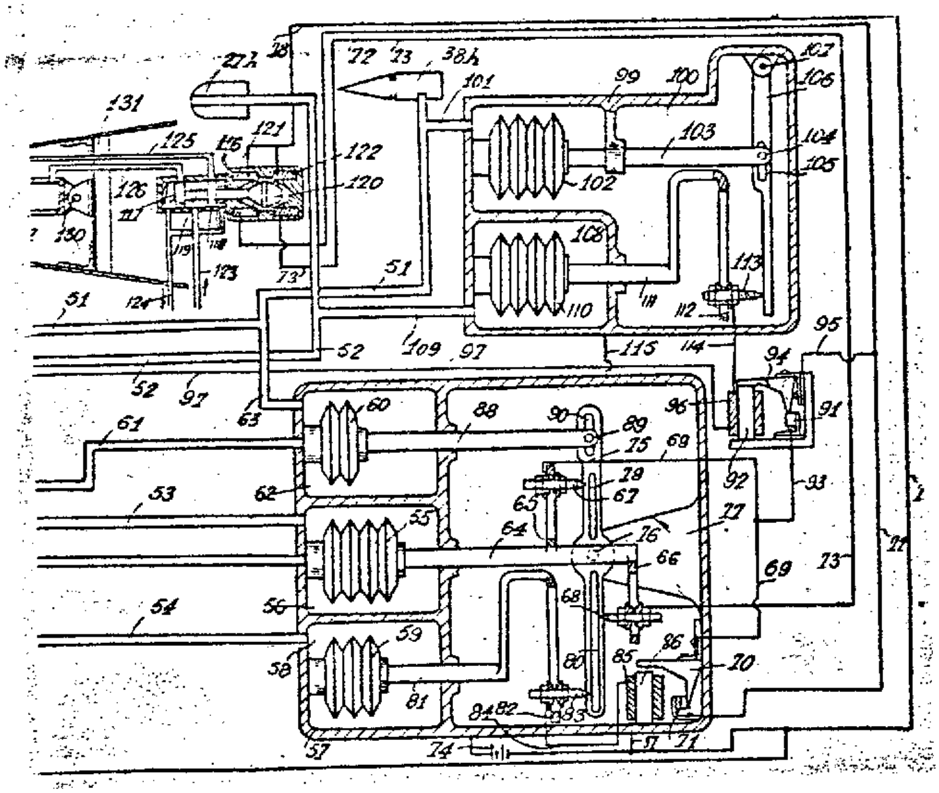


Fig. 7

As soon as the aircraft reaches a supersonic speed corresponding to a Mach number greater than that for which the control unit 99 has been set, the effects of static pressure on capsule 102 override the effects of Pitot pressure on capsule 110. The circuit established by closing contact 113 on lever 106 is now broken, which de-energizes windings 50 and 96. Core 48 is retracted by spring 134, with the result that the pressure existing in intake 5h is transmitted to chamber 56 and the static pressure to chamber 58 and capsule 60, capsule 55 being subjected to the pressure existing at intake 6h, and chamber 62 to the static pressure. Capsule 55 undergoes deformation proportional to the difference in rear and forward pressures measured at 6h and 5h on the inner surface of the contoured panel 1h in relation to the air intake, while capsule 60, subjected to the effects of static pressure in a chamber which is itself subjected to the effects of static pressure, undergoes no deformation and serves to keep lever 75 in neutral position. The deformation of capsule 59, and consequently the movement of contact 83, is proportional to the static pressure, and, at the point when this contact becomes connected with contact 80, determines the fraction of the static pressure constituting the positive limit above which the difference between the rear and forward pressures corresponds to a correct position for flap 2h. One of the following three possibilities may occur: /7

a. If the rear pressure exceeds the forward pressure but their difference is still less than the value of this fraction of the static pressure, contact 67 closes on contact 79, assuring a supply of current to line 72 from circuit breaker 70 and contact 71, the oil distributor and the hydraulic cylinder operate as previously indicated in Case (a) and the angle of deflection of flap 2h is closed;

b. If the rear pressure is lower than the forward pressure, contact 68 closes on contact 80, assuring a flow of current in line 73; the oil distributor and the hydraulic cylinder operate as previously indicated in Case (b) and the angle of deflection of flap 2h is opened;

c. If the difference between the rear pressure and the forward pressure is greater than the fraction of the static pressure under consideration, contact 83 closes on contact 80, assuring excitation of winding 85 through line 84. Circuit breaker 70 is attracted, which interrupts the current in line 72, which furthermore can no longer be supplied by line 95 since circuit breaker 94 has been opened by the de-energizing of winding 96. No effects on the oil distributor are obtained, and flap 2h consequently remains in its present position.

So that the circuit established by contacts 67 and 79 is not prematurely broken by contacts 83 and 80 and by circuit breaker 70, line 72 is directly connected to the contact by means of lines 69 and 95 and by means of contact 94, which is closed only at subsonic speeds. In addition, so that the positive fraction of the dynamic pressure is not decreased by the interaction of contact 83, the movement of this contact caused by the Pitot pressure must be greater than the movement of lever 75 before this fraction of the dynamic pressure may be attained.

Operation of the control system is assured for all speeds if the distances of contacts 67, 68 and 83 and shaft 88 from shaft 64, as well as the effective surface area and elasticity coefficient characteristics of capsules 55, 59 and 60, are determined in such a way that in subsonic operation the flow may be admitted between the positive and negative fractions of the dynamic pressure and in supersonic operation no adjustment is made if the difference in the rear and forward pressures is greater than the predetermined fraction of the static pressure, and if the change in connection of the different conduits caused by valve 42 and control device 99 occurs at an appropriate Mach number ranging from 1 to 1.3, determined by the distances of shaft 103 and contact 113 from shaft 107 and by the effective surface area and elasticity characteristics of capsules 102 and 110.

In the case of an air intake with two contoured panels, an analogous device serves for the automatic control of flap 2i of the second contoured panel of the air intake, as a function of the pressures existing at its intakes 5i, 6i and 7i, respectively internal to and external to the intake (Fig. 6). For the purpose of simplification, the conduits of the pressure intakes on the two contoured panels may be connected to a single device controlling two paired cylinders, one for each panel.

It is quite obvious that changes may be made in the device described without departing from the general framework of the present invention.

<u>Summary</u>

The object of the present invention is:

1. An improvement in sharp leading edge airfoils characterized by the fact that the airfoil is equipped with a deflecting or slotted flap with sharp leading edge.

2. A process for adaptation of a contoured air intake panel to any given speed, subsonic or supersonic, this panel consisting of a deflecting or slotted flap with sharp leading edge as specified in (1); in this process the flow on this flap is measured for each subsonic speed and the deflection of this flap is adjusted until this flow is tangential to the flap, while at each supersonic speed the position of the shock wave in relation to this flap is determined and the deflection of the flap is adjusted in such a /8
way that the shock wave is located on its sharp edge or in the im-

mediate vicinity of this sharp edge.

3. Methods of application of the process specified in (2) offer the following characteristics:

a. At subsonic speeds, the difference between the external and internal pressures measured at two neighboring points on the flap equidistant from the sharp edge and located respectively on the inner and outer surfaces of the flap profile in relation to the intake are measured, the difference in pressure is compared to two negative and positive fractions of the dynamic pressure of the undisturbed flow definitively determined for the airfoil under consideration, and the flap is pivoted to close or open the angle of deflection, depending on whether the pressure difference is less than the negative fraction or greater than the positive fraction of this dynamic pressure; then, at supersonic speeds the difference between the rear and forward pressures measured at two distinct points located on the inner surface of the flap profile in relation to the intake in the vicinity of the sharp edge is measured, this pressure difference is compared to a predetermined fraction of the ambient static pressure, and the flap is pivoted to close or open the angle of deflection, depending on whether the pressure difference is positive or negative and smaller than this fraction of the ambient static pressure;

b. The measurement point on the outer surface and the rear measurement point on the inner surface of a single contoured panel are located at the same distance from the sharp edge of the flap;

c. In cases where the aircraft is capable of flying only at subsonic speeds, the process of adaptation of the contoured intake panel(s) to the speed of the aircraft consists only in the first part of the method of application specified in (3)a.

4. An adaptation device permitting implementation of the process specified in (2) and (3); this device includes a detector of the relative position in the airstream of the deflecting or slotted flap with sharp leading edge of each contoured air intake panel, a dynamic pressure detector estimating the speed of the aircraft, a static pressure detector, a synchronizer of the variations produced by the first and the second detector for subsonic flight and by the first and third detectors for supersonic flight, this synchronizer serving to convert the results obtained into mechanical movement or electrical activity, and an indicator for the pilot showing the direction of the change to be made in the deflection of the flap of each contoured panel, this indicator capable of being replaced by an automatic control device modifying the deflection of the flap in conformity with the results obtained by the synchronizer.

5. Designs for realization of the device specified in (4) show the following major characteristics, either individually or in any possible combination:

a. The adaptation device includes a unit measuring two negative and positive fractions of the dynamic pressure of the undisturbed flow; a second unit measuring a fraction of the ambient static pressure; a manometric unit measuring pressure differences; two pipes connected to this manometric unit, one of them terminating in an intake located on the inner surface of the flap in relation to the air intake, while the other may be connected either to a second intake located on the outer surface of the flap in relation to the air intake and at the same distance from the sharp edge as the first intake, or to a third intake located on the inner surface of the flap upstream from the first intake; a device to be used at subsonic speeds to compare the difference between the external and internal pressures measured for the first and second intakes and the negative and positive fractions of the dynamic pressure of the undisturbed flow; a device to be used at supersonic speeds to compare the measured pressure difference between the first and third intakes and the fraction of the ambient static pressure; and a manually or automatically controlled means of changing the deflection of the flap as a function of the data furnished by the comparative devices;

b. In cases where the aircraft is used only for subsonic flight, the device described in (5)a includes only the first measurement unit, the manometric unit for pressure difference measurement, the first comparative device and the manual or automatic means of changing the deflection of the flap of each contoured air intake panel, the second pipe being connected only to a second intake located on the outer surface of the flap in relation to the air intake at the same distance from the sharp edge as the first intake;

c. The adaptation device includes a distributor which receives the pressures measured at the various intakes of the flap of the contoured air intake panel, the differences in these pressures being transmitted to a control device which controls a servo motor designed to change the angle of deflection of the flap;

d. The control devices and the servo motor operate semiautomatically or automatically and these devices may be powered mechanically, electrically, hydraulically or pneumatically;

e. In the case of air intakes equipped with a core, the adap- /9
tation device is combined with a circular intake with sharp leading edge, the movements of the core replacing the variation in deflection of the leading edge;

f. If the air intakes are not provided with a core they will include one or two deflecting flaps with sharp leading edge, depending on whether these intakes are dorsal, lateral, embedded or located in the wing root.

6. Applications of the process specified in (3)c and the device specified in (5)b to the sharp leading edge airfoils used in wings and stabilizers for subsonic flight, the deflecting flap, however, being kept in a fixed position for supersonic flight, this flap being divided into several independent and separately controlled parts in the case of

Requested at 16:35 hours, November 19, 1952, in Paris.
Issued March 3, 1954. Published August 27, 1954.
(Issuance of this patent was delayed in execution of Art. 11, § 7, of the statute of July 5, 1844, modified by the statute of April 7, 1902.)